Annexure-2

M.Tech in Semiconductor and Quantum Technology
Scheme of Study (July 2026)

FIRST SEMESTER:

COURSE CODE	Title of the Course	Periods per week			Credit
		L	T	P	
PY SQ 1101	Physics of Semiconductor Devices	3	-	-	3
EC VE 1101	VLSI Design	3	-	-	3
CS QC 1101	Introduction to Quantum Computing	3	-	-	3
PY SQ 1151-59	Elective-1	3	-	-	3
PY SQ 1161-69	Elective-2	3	-	-	3
CS QC 1104	Quantum Programming Lab	-	-	2	1
EC VE 1105	VLSI Front End Design Lab	-	-	2	1
PY SQ 1106	Seminar-1	-	-	2	1
PY SQ 1107	Minor Project-1(Self Learning)			4	2
Total Hours = 25 **Total Cumulative Credits:20**		**Total Semester Credits**			**20**
Open Audit Course					
*HS 1101 Communication Skills 02 Credits (Compulsory Audit Course Not Counted in SGPA/CGPA Calculations)					

SECOND SEMESTER:

COURSE CODE	Title of the Course	Periods per week			Credit
		L	T	P	
PY SQ 1201	Processing and Fabrication of Semiconducting Quantum Materials	3	-	-	3
MC MT 1201	Quantitative Methods	3	-	-	3
PY SQ 1251-59	Elective-3	3	-	-	3
PY SQ 1261-69	Elective-4	3	-	-	3
PY SQ 1281-99	Open Elective	3	-	-	3
PY SQ 1203	Synthesis Lab	-		2	1
PY SQ 1204	Characterization Lab	-		2	1
PY SQ 1205	Seminar-2	-	-	2	1
PY SQ 1206	Minor Project-2 (Self Learning)			4	2
Total Hours = 25 **Total Cumulative Credits:40**		**Total Semester Credits**			**20**

THIRD SEMESTER:

COURSE CODE	Title of the Course	Periods per week			Credit
		L	T	P	
PY SQ 2101	Dissertation Phase-I	-	-	40	20
Total Hours = 40 **Total Cumulative Credits:60**		**Total Semester Credits**			**20**

FOURTH SEMESTER:

COURSE CODE	Title of the Course	Periods per week			Credit
		L	T	P	
PY SQ 2201	Dissertation Phase-II	-	-	40	20
Total Hours = 40 **Total Cumulative Credits:80**		**Total Semester Credits**			**20**

Grand Total of Course Credits = 20 + 20 + 20 + 20 = 80

List of Program Electives

Semester -I			
List of Electives - 1		**List of Electives - 2**	
Sub Code	**Elective Subject Name**	**Sub Code**	**Elective Subject Name**
PY SQ 1151	Functional Properties of Materials & Devices	PY SQ 1161	Nanoelectronics and Nanophotonics
PY SQ 1152	Magnetism and Superconductivity	PY SQ 1162	Carbon Nanomaterials
PY SQ 1153	Fundamentals of Quantum Materials	CS QC 1103	Quantum Algorithm and Complexity
Semester -II			
List of Electives - 3		**List of Electives - 4**	
Sub Code	**Elective Subject Name**	**Sub Code**	**Elective Subject Name**
PY SQ 1251	Thin Film & Vacuum Technology	PY SQ 1261	Materials Science and Engineering
PY SQ 1252	Solar Photovoltaic and Energy Storage	PY SQ 1262	Materials Properties at Low Temperatures
PY SQ 1253	Instrumentations	PY SQ 1263	Defects in Materials
CS QC 1201	Quantum Machine Learning and Deep Learning	PY SQ 1264	Optoelectronics

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: I**	**Year: 2026**
Name of Course	**Physics of Semiconductor Devices**		
Course Code	**PY SQ 1101**		
Core / Elective / Other	**Core**	**Credit: 3**	

Course Objective:

The objective of this course is to provide students with a comprehensive understanding of electronic properties of solids and semiconductors. The course explores semiconductor physics in depth covering band structure, carrier statistics and transport phenomena. In addition, the formation of semiconductor junctions and their applications for a diode, BJT, MOSFETs and finally the integration for circuits for logic gates will be studied.

Course Outcomes:

- CO1: Semiconductor Materials and Devices
- CO2: Formation and implications of energy bands in solids
- CO3: Describe and evaluate semiconductor properties, including band structure, intrinsic and extrinsic carrier concentrations, and the role of Fermi energy
- CO4: Semiconductor junctions and diode
- CO5: BJT, MOSFET, and integration of circuits.

Syllabus

Basic properties of semiconductors: Crystallography structures, energy bands, Intrinsic and extrinsic semiconductors, drift and diffusion of charge carriers. Formation of p-n junction and applications. Bipolar Junction Transistors (BJT): Common base, common emitter, and common collector configurations, Input and output characteristics, Current gain and transistor parameters. Junction Field Effect Transistor (JFET), Metal Oxide Semiconductor Field Effect Transistor (MOSFET), CMOS technology and applications, Thin film transistors and flexible electronics, Integration of circuits for logic gates. Basic steps for semiconductor device fabrication and characterization.

List of Text Books:

1.	Semiconductor Physics and Devices by Donald A. Neamen
2	Physics of Semiconductor Devices by S. M. Sze
3	Solid State Electronic Devices by Ben G. Streetman
4	Materials Science and Engineering: V. Ragahvan (Prentice Hall)
5.	Introduction to Solid State Physics: Charles Kittel

List of Reference Books:

1.	Materials Science and Engineering: V. Ragahvan (Prentice Hall)

2.	Materials Science and Engineering, W.D. Callister (John Wiley & Sons, USA)
3.	Elements of X-ray diffraction, B. D. Culity (Pearson, UK)
4.	Introduction to Magnetic Materials, B. D. Culity (Wiley, USA)
5.	Nanocomposite Science and Technology, Ajayan, Schalder & Barun (John Wiley & Sons)
6.	Materials Science and Technology: Sabar D. Hutagalung (Intech Publishers)
URLs:	
1.	https://nptel.ac.in/courses/115/106/115106127/
2.	https://nptel.ac.in/courses/115/104/115104109/
3.	https://nptel.ac.in/courses/122/107/122107035/
4.	https://nptel.ac.in/courses/115/105/115105099/
5.	https://podcasts.ox.ac.uk/series/oxford-solid-state-basics

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: I**	**Year: 2026**
Name of Course	**VLSI Design**		
Course Code	**EC VE 1101**		
Core / Elective / Other	**Core**	**Credit: 3**	

Course Objective:

To provide students with fundamental knowledge of MOS and CMOS technologies, VLSI design methodologies, logic circuit design, scaling concepts, layout techniques, and ASIC design principles for modern integrated circuit applications.

Course Outcomes:

- CO1. Recall concepts of IC manufacturing and basics of CMOS technology, ASIC's. FPGAs, PLA & PLA.
- CO2. Outline physical design of logic gates, CMOS logic structure, power dissipation in CMOS, and discuss about behavioral synthesis.
- CO3. Explain locking strategies, clock skew, timing issues, static and dynamic timing analysis.
- CO4. Explain CMOS testing, manufacturing test principles, design strategies for chip and system level test techniques.
- CO5. Illustrates basics of CMOS technology, ASIC's, FPGAs, PLA & PAL.

Syllabus

Introduction to MOS Technology- CMOS fabrication. Basic Electrical Properties – MOS Inverter, Zpu/Zpd rato, CMOS Inverter, Regions of Operation, BiCMOS Inverters. Scaling – Scaling models and factors, scaling factors for various device parameters. MOS Circuits and logic design: Switching logic, gate logic, Two/Three input NMOS, CMOS & BiCMOS, NAND & NOIR gates, CMOS logic structures – Pseudo nMOS, dynamic CMOS, clocked CMOS, CMOS domino, NP-domino logic, clocking strategies. Introduction of VLSI Design Methodologies -Design Description domains. System design and methods – CMOS design methods, CMOS design options. Layout design rules and Stick diagrams. Introdduction to ASIC Design.

List of Text Books:

1.	Basic VLSI Design, Pucknell and Eshraghian
2.	Principles of CMOS VLSI design, Weste and Eshraghian

List of Reference Books:

1.	CMOS VLSI Design Harris, Weste, Banerjee
2.	CMOS Circuit design, Baker, Willi, Boyce

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: I**	**Year: 2026**
Name of Course	**Introduction to Quantum Computing**		
Course Code	**CS QC 1101**		
Core / Elective / Other	**Core**	**Credit: 3**	

Course Objective:

To introduce the principles of quantum computing, including qubits, quantum gates, superposition, entanglement, and measurement, while exploring quantum vs classical computation, decoherence, NISQ devices, quantum error correction, cryptography, and real-world implementations, along with societal and ethical considerations in the evolving quantum landscape.

Course Outcomes:

1. Understand the historical evolution and motivation behind quantum computing.
2. Distinguish classical vs quantum computational paradigms and their power.
3. Explain fundamental concepts like qubits, superposition, entanglement, measurement.
4. Discuss physical realizations and architecture of quantum computers.
5. Appreciate the challenges and current state of quantum technology.

Syllabus

Historical motivation for quantum computing, classical vs quantum information processing, qubits and multi-qubit systems, Bloch sphere visualization, quantum superposition and entanglement, measurement and collapse postulate, Bell inequalities and non-locality, basics of quantum gates and circuits, circuit vs measurement-based quantum computing, introduction to decoherence and noise, NISQ devices and quantum supremacy, quantum error correction overview, physical implementations (superconducting qubits, trapped ions, photonics), introduction to quantum cryptography, ethical and societal implications of quantum technologies, current quantum industry landscape.

List of Text Books:

1.	Quantum Computation and Quantum Information by Nielsen & Chuang
2.	Quantum Computing: A Gentle Introduction by Eleanor Rieffel and Wolfgang, Polak, MIT Press

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: I**	**Year: 2026**
Name of Course	**Quantum Programming Lab**		
Course Code	**CS QC 1104**		
Core / Elective / Other	**Core**	**Credit: 1**	

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**VLSI Front End Design Lab**		
Course Code	**EC VE 1105**		
Core / Elective / Other	**Core**	**Credit: 1**	

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: I**	**Year: 2026**
Name of Course	**Seminar-1**		
Course Code	**PY SQ 1106**		
Core / Elective / Other	**Core**	**Credit: 1**	

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: I**	**Year: 2026**
Name of Course	**Minor Project-1 (Self Learning)**		
Course Code	**PY SQ 1107**		
Core / Elective / Other	**Core**	**Credit: 2**	

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Processing and Fabrication of Semiconducting Quantum Materials**		
Course Code	**PY SQ 1201**		
Core / Elective / Other	**Core**	**Credit: 3**	

Course Objective:

In this is course we introduce fundamental of Nanotechnology to control the size of a material for processing and fabrication of nanostructures.

Course Outcomes:

- CO1. Introducing the students to advanced technology of controlling the size of a material for fabrication of nanomaterials
- CO2. Different sophisticated techniques are introduced for processing and fabrication of nanaomaterials
- CO3. Detailed study of the advanced techniques include: Lithography, Molecular beam epitaxy (MBE), self assembly.
- CO4. In depth knowledge to the students about the current state of art of nanomaterials fabrication

Syllabus

Top-Down Synthesis Techniques: Physical Vapor Deposition (PVD) (Thermal evaporation, sputtering, and molecular beam epitaxy (MBE)), Chemical Vapor Deposition (CVD) (Growth of 2D materials like graphene and TMDs) Lithography and Etching (Fabrication of quantum wells, wires, and dots), Ion Beam Techniques (Ion implantation for doping and nanostructuring), Mechanical Exfoliation (For producing monolayer and few-layer 2D materials). Bottom-Up Synthesis Techniques: Colloidal Synthesis (Wet chemical methods for quantum dots and nanocrystals), Sol-Gel Method (For thin films and nanoparticle formation), Hydrothermal and Solvothermal Methods (Synthesis of nanowires, nanotubes, and complex nanostructures), Self-Assembly (Controlled assembly of nanoparticles into superlattices), Atomic Layer Deposition (ALD) (Ultra-thin film growth with atomic precision).

Advanced Synthesis Methods: Plasma-Assisted Techniques (Plasma-enhanced CVD and sputtering for defect-free materials), Molecular Beam Epitaxy (MBE) (Growth of high-purity epitaxial layers), Electrochemical Deposition (Synthesis of thin films and nanostructures), Laser Ablation and Pulsed Laser Deposition (PLD) (For growing thin films and nanostructures), Microwave-Assisted Synthesis (Rapid synthesis of nanoparticles and quantum dots), Core-Shell Structures (Strategies for enhancing stability and optical properties). Post-Synthesis Processing and Modification: Annealing and thermal treatments for crystallinity improvement Doping and alloying for tailored electronic and optical properties Surface functionalization for stability and application-specific tuning Defect engineering for enhanced performance Integration of synthesized materials into

heterostructures and devices.	
List of Text Books:	
1.	Hand Book of Semiconductor Cleaning Technology: Werner Kern (William Andrew)
2.	Principles of Lithography: Harry J. Lavinson, (SPIE Press)
3.	Introduction to Nano Science and Nanotechnology: Chris Binns, (Wiley-VCH)
4.	Self-Assembly and Nanotechnology, A force Balance Approach: Yoon S. Lee (John Wiley & Sons Publication)
List of Reference Books:	
1.	Nanostructured Materials: Mohinder Seehra (Intech Open Publishers)
2.	Nanostructures: Nejo, Hitoshi (Springer)
3.	G. E. Dieter, adapted by D Bacon, "Mechanical Metallurgy", SI Metric edition, (McGraw Hill Publishers)
URLs:	
1.	https://www.intechopen.com/books/nanostructured-materials-fabrication-to-applications
2.	https://application.wiley-vch.de/books/sample/3527326758_c01.pdf
3.	https://nptel.ac.in/content/storage2/courses/117104022/Lectures/Lec8.pdf
4.	http://www.cityu.edu.hk/phy/appkchu/AP6120/5.PDF

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Quantitative Methods**		
Course Code	**MC MT 1201**		
Core / Elective / Other	**Core**	**Credit: 3**	

Course Objective:

By the end of the course, students will be able to organize, analyze, visualize, and interpret statistical data using appropriate statistical methods, correlation and regression techniques, and curve fitting models for scientific and practical applications.

Course Outcomes: After completion of the course, the students will be able to

- CO1. To introduce the fundamental concepts of statistics, including data types, data collection methods, sampling techniques, and data management practices.
- CO2. To develop the ability to organize and present statistical data through tables, graphs, histograms, and visualization tools.
- CO3. To enable students to compute and interpret measures of central tendency, dispersion, skewness, and kurtosis for statistical analysis.
- CO4. To provide knowledge of correlation and regression techniques for studying relationships between variables and estimating model parameters.
- CO5. To familiarize students with curve fitting methods and least square techniques for linear and non-linear data modeling and analysis.

Syllabus

Statistical meaning, data types, sources, collection, record-keeping, and file management. Sampling, including simple random and stratified methods. Data organization: Individual, discrete, and continuous series; Data Presentation - Statistical tables, comparison methods, graphic charts, and histograms. Presentation software like Ogive can be used for data visualization. Statistical methods: Central tendency: arithmetic mean, median, mode, geometric mean, harmonic mean. Measure of Dispersion: absolute dispersion, range, quartile deviation, average deviation, standard deviation, variance, skewness, and kurtosis. Correlation: Definition, Types and Degree of Correlation, Correlation co-efficient; Estimation of correlation co-efficient methods; Rank Correlation, Repeated Rank Correlation, Estimation of Rank Correlation coefficient. Regression: Definition and Types of Regression, Estimation of Line of Regression, Coefficient of regression estimation methods, Estimating Model Parameters: Principle of Least Square Method. Curve Fitting: Overview of curve fitting: Definitions and applications. Differences between interpolation, regression, and curve fitting. Methods for Curve Fitting: Least Square Method, Linear Fitting: Best Fit of Straight line, Non-linear Fitting: Best fit of Parabola, best fit of Exponential, Logarithmic and Power-law Functions.

List of Text Books:	
1.	Applied Statistics and Probability for Engineers, Montgomery and Runger
2.	Fundamentals of Mathematical Statistics, Gupta and Kapoor
List of Reference Books:	
1.	Introduction to Probability and Statistics, Mendenhall, Beaver, and Beaver
2.	Probability and Statistics for Engineers and Scientists, Walpole, Myers, Myers, Ye

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Synthesis Lab**		
Course Code	**PY SQ 1203**		
Core / Elective / Other	**Core**	**Credit: 1**	

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Characterization Lab**		
Course Code	**PY SQ 1204**		
Core / Elective / Other	**Core**	**Credit: 1**	

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Seminar-2**		
Course Code	**PY SQ 1205**		
Core / Elective / Other	**Core**	**Credit: 1**	

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Minor Project-2 (Self Learning)**		
Course Code	**PY SQ 1206**		
Core / Elective / Other	**Core**	**Credit: 2**	

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: III**	**Year: 2026**
Name of Course	**Dissertation Phase-I**		
Course Code	**PY SQ 2101**		
Core / Elective / Other	**Core**	**Credit: 20**	

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: IV**	**Year: 2026**
Name of Course	**Dissertation Phase-II**		
Course Code	**PY SQ 2102**		
Core / Elective / Other	**Core**	**Credit: 20**	

Grand Total of Course Credits = 20 + 20 + 20 + 20 = 80

List of Program Electives

Semester -I			
List of Electives - 1		**List of Electives - 2**	
Sub Code	**Elective Subject Name**	**Sub Code**	**Elective Subject Name**
PY SQ 1151	Functional Properties of Materials & Devices	PY SQ 1161	Magnetism and Superconductivity
PY SQ 1152	Nanoelectronics and Nanophotonics	PY SQ 1162	Computational Methods
PY SQ 1153	Carbon Nanomaterials	PY SQ 1163	Materials Properties at Low Temperatures
PY SQ 1154	Instrumentation	CS QC 1103	Quantum Algorithm and Complexity
Semester -II			
List of Electives - 3		**List of Electives - 4**	
Sub Code	**Elective Subject Name**	**Sub Code**	**Elective Subject Name**
PY SQ 1251	Thin Film & Vacuum Technology	PY SQ 1261	Research Methodology
PY SQ 1252	Solar Photovoltaic and Energy Storage	PY SQ 1262	Materials Science and Engineering
PY SQ 1253	Laser Technology	PY SQ 1263	Defects in Materials
CS QC 1201	Quantum Machine Learning and Deep Learning	PY SQ 1264	Optoelectronics

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: I**	**Year: 2026**
Name of Course	**Functional Properties of Materials & Devices**		
Course Code	**PY SQ 1151**		
Core / Elective / Other	**Elective - 1**	**Credit: 3**	

Course Objective: To provide a comprehensive understanding of Ceramic Capacitors, piezoelectric, ferroelectric and electro optic ceramics - material systems, processing and fabrication. Also understanding Smart functional role of the materials in devices which depends on their electrical, optical and thermal properties.

Course Outcomes:

- CO1: Understanding fundamental principles: defect chemistry, ionic conductivity, ceramic electrolytes and fast ion conductors, ceramic insulators
- CO2: Understand the Working principle of the Electrochromic thin film technology, materials and deposition methods, application of thin films in microelectronics and microsystems
- CO3: Analyze the Smart functional role of the materials in devices which depends on their electrical, optical and thermal properties.
- CO4: Study of Ceramic sensors and resistors- classification, operating principles of different sensors, preparation and applications
- CO5: Investigate Ceramic membranes- classifications, material requirements, preparation and applications, special glass and glass ceramics for defense applications.

Syllabus:

Functional ceramics, classification according to their different functions, electrical and electronic conduction in ceramics, defect chemistry, ionic conductivity, ceramic electrolytes and fast ion conductors, ceramic insulators; Ceramic Capacitors, piezoelectric, ferroelectric and electro optic ceramics - material systems, processing and fabrication

Electrochromic thin film technology, materials and deposition methods, application of thin films in microelectronics and microsystems; Multilayer ceramic technology- processing of multi-layer ceramics, sintering of multilayer structure, low temperature co-fired glass ceramics

Smart functional role of the materials in devices which depends on their electrical, optical and thermal properties, smart transducers, optical fibers, optical coatings, liquid crystal displays, optical storage devices, ruby laser, solar cell, ceramic insulators, Peltier cooler

Ceramic sensors and resistors- classification, operating principles of different sensors, preparation and applications; Positive and negative temperature coefficient ceramic thermistors, gas, humidity and pressure sensors, ZnO varistors technology, varistor microstructure and fabrication, Varistor application

Ceramic membranes- classifications, material requirements, preparation and applications, special glass and glass ceramics for defense applications

List of Text Books:

1.	Ceramic Materials for Electronics, R. C Buchanan, 3rd Ed, Marcel Dekker, NY 2004
2.	Electroceramics: Materials, Properties and Applications, A.J. Moulson and J.M. Herbert, Wiley; 2nd Ed. 2003
3.	Low Thermal Expansion Glass Ceramics, H. Bachs and D. Krause, Springer, 2005
4.	Electroceramic based MEMS: Fabrication Technology and Applications, N. Setter, Springer 2005
5.	Ceramic Sensors: Technology and Applications, T. G. Nenov, S. P. Yordanov and N. Nenov, CRC Press 1996
6.	Z. L. Wang, W. Z. L. Wang and Z. C. Kang, "Functional and Smart Material", Springer 1998
7.	Piezoelectric Ceramics, B. Jaffe, W. R. Cook, H. Jaffe and H. L. C. Jaffe, R.A.N Publishers 1990
8.	Deborah D. L. Chung, Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Magnetic Applications Vol. 4 ,World Scientific, 2022

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Magnetism and Superconductivity**		
Course Code	**PY SQ 1152**		
Core / Elective / Other	**Elective – 1**	**Credit: 3**	

Syllabus:

Diamagnetism Isolated magnetic moments Magnetism in 3d and 4f atoms/ions, Hund's rules, crystalline electric field effects Curie, van Vleck and Pauli Paramagnetic Spontaneous magnetic order Molecular field models, Magnetic order in elements, alloys and non-metallic compounds – Exchange interactions, Heisenberg direct exchange, itinerant exchange, Stoner parameter, Double exchange, Super exchange, RKKY exchange Spin glass, cluster glass, and Kondo effect, Statistical mechanics of magnetism in solids, Landau-Ginzburg-Wilson theory, Ising model – spin waves – Bloch T3/2 law Magneto crystalline anisotropy Magnetism and magnetic interactions in sub-micron level particles, phenomenon of superparamagnetic, magnetism in thin films

Superconductivity: Properties of superconductor in normal state, Fundamental phenomena: Perfect conductivity and Meissner effect, thermodynamic critical field, other physical properties of superconductors. Electrodynamics of superconductors: London equations and penetration depth, superconductor as a macroscopic quantum state, flux quantization. Thermodynamics of the superconducting phase transition, Ginzburg -Landau theory, order parameter, Type I and Type II superconductors. Transport current, critical current density and critical magnetic fields. Surface nucleation and critical magnetic field, Hc_2. Nature of mixed state Structure of a vortex, flux flow, vortex pinning and critical current density. Microscopic (BCS) theory. Cooper pairs and the attractive interaction. BCS ground state and excitations from the ground state. Energy gap and its temperature dependence. Tunneling experiments. Josephson effect, Superconducting Quantum Interference Device (SQUID). High temperature oxide and iron-based superconductors.

List of Text Books:

1.	D.H. Martin, Magnetism in Solids, ILIFFE Books Ltd, (1967)
2.	A.H. Morrish, Physical Principles of Magnetism, John Wiley, New York (1965)
3.	P. Mohn, Magnetism in Solid State, an Introduction, Springer (2006)
4.	B.D. Cullity and C.D. Graham, Introduction to Magnetic Materials, Wiley (2009)
5.	Michael Tinkham, Introduction to Superconductivity, 2nd edition, Dover books on Physics Vol. I (2004)
6.	J.B. Ketterson and S.N. Song, Superconductivity, Cambridge University Press (1999)
7.	Stephen Blundell, Magnetism in Condensed Matter, Oxford University Press, 2001
8	Charles P. Poole, H. A. Farach, R. J. Creswick, R. Prozorov, Superconductivity, Elsevier (2010)

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: I**	**Year: 2026**
Name of Course	**Fundamentals of Quantum Materials**		
Course Code	**PY SQ 1153**		
Core / Elective / Other	**Elective-1**	**Credit: 3**	

Course Objective:

In this is course we focus on Characteristic scale for quantum phenomena- Quantum Confinement. Drexler-Smalley debate and historical and environmental evidences. Also study properties and application of Nano Materials. Micro & Nano Electromechanical Systems.

Course Outcomes:

- CO1. To introduce the theoretical concepts of nanotechnology with the help of different models.
- CO2. Detailed study of types of nanomaterials -1D,2D,3D nanomaterials
- CO3. Introduce the students to most important nanomaterial C_{60} and Fullerene. Their structure and bonding which makes them special
- CO4. Different properties like transport thermal and mechanical properties of nano tubes to be studied in detail
- CO5. Application of nanomaterials in advanced technology like NEMS and MEMS.

Syllabus

Introduction to Quantum Materials (QM): Overview of quantum materials and their classifications (2D materials, nanowires, quantum dots, etc.), Quantum confinement effects and their impact on material properties, Differences between bulk and low-dimensional QM, Structural and compositional diversity in quantum materials, Crystal structures, lattice symmetries, and surface properties

Electronic and Optical Properties: Density of states in 0D, 1D, 2D, and 3D QM, Energy bandgap engineering and quantum size effects, Carrier recombination processes and mobility, Defect states and their influence on electrical conductivity, Optical transitions: direct vs. indirect bandgap materials, Photoluminescence, electroluminescence, and Raman spectroscopy, Applications of quantum dots in LEDs and lasers, Nonlinear optical phenomena and multi-photon absorption.

Magnetic and Thermal Properties: Different states of magnetic and superconducting quantum materials. Spin Hall effect, Thermal Hall effect, Nernst effect, Rashba effect, spin-orbit coupling, Josephson effect and junctions. Role of dimensionality in magnetic ordering, Spin waves, Applications in spintronics, thermoelectric, and magnetic sensors. Surface and Mechanical Properties: Surface energy, surface interactions, adhesion and wetting properties, mechanical properties at the nanoscale, elasticity and plasticity, hardness, stress and strain analysis, strain engineering, quantum size effects, material stability and reactivity, influence of defects and dislocations on mechanical behavior, applications in microelectronics and nanotechnology.

List of Text Books:	
1.	Interacting Electrons and Quantum Magnetism: A. Auerbach (Springer New York)
2.	D. Bimberg, M. Grundman, N.N. Ledenstov: Quantum Dot Heterostructure (World Scientific Singapore)
3.	Nanoscience and Nanotechnology: Shubra Singh M.S. Ramachandra Rao (Wiley – VCH)
4.	Introduction to Nano Science and Nanotechnology: Chris Binns, (Wiley-VCH)
5.	Quantum Theory of Magnetism: Wolfgang Nolting & Anupuru Ramakanth (Springer Berlin Heidelberg)
List of Reference Books:	
1.	Advances in Nanomaterials: Balasubramanian, Ganesh (Springer)
2.	Nanoscience and Nanotechnology: Advances and Developments in Nano-sized Materials: Marcel Van de Voorde (De Gruyter Publishers)
URLs:	
1.	http://www.physics.dcu.ie/~jpm/PS407/dot.pdf
2.	https://www.nanotech-now.com/
3.	https://nptel.ac.in/courses/113/106/113106040/
4.	http://stanford.edu/~oas/SI/QM/papers/QMGreensite.pdf

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: I**	**Year: 2026**
Name of Course	**Nanoelectronics and Nanophotonics**		
Course Code	**PY SQ 1161**		
Core / Elective / Other	**Elective - 2**	**Credit: 3**	

Course Objective: This course aims to introduce students to the fundamentals and applications of spintronics, nanoscale solid-state devices, nanophotonics, and liquid crystals. It covers key concepts such as spin injection, magnetoresistance effects, quantum confinement, photonic bandgap materials, and nanoscale optical phenomena, along with the unique properties and applications of liquid crystals in modern nanoelectronics and photonics.

Course Outcomes:

- CO1. To study the concept of spin associated with the electron and its usability for various engineering applications and memory devices.
- CO2. To study injection of spin and its transport through the required medium.
- CO3. To understand the phenomenon of Giant Magneto -resistance (GMR) and spin valve effect.
- CO4. To understand quantum confinement effect and to study applications of the structures showing quantum confinement effect.
- CO5. Study of Photonic band gap material and nanoscale photonic devices.

Syllabus:

Nano-electronics: Review on electron energy bands in metals and semiconductor nanostructure, quantum confinement, 0D to 3D functional nanomaterials and hybrids. Electron transport in nanostructures: Classical dissipative transport, Dissipative transport in short structures, hot electrons, Classical and Quantum ballistic transport, Quantized conductance, Single electron transport, and Coulomb blockade, Resonant-tunneling diodes, Single-electron transistor, flexible optoelectronics devices, Nanoelectromechanical system.

Spintronic: Spin Injection, GMR & TMR, Spin valve effect, spin valves and MRAM Devices, Solid state devices: quantum dots, quantum wires, quantum well, Nanophotonic: Photonic bandgap materials, nanoscale photonic devices, Special phenomena in 2D and 3D nano structures

Liquid crystals: The basic properties of liquid crystals and their display and non-display applications at the nanoscale.

Nanophotonic: Photons and Electrons, Optics at nanoscale, Energy transport by evanescent waves, Frustrated total internal reflection. Dyadic Green's Function formulation for electric field, time-dependent Green's function, Maxwell's stress tensor, radiation pressure, forces in optical near fields. Quantum emitters and detectors, Surface plasmons in nanostructures, Concept of SERS, Photonic crystal, Optical micro-resonators, Cavity enhanced absorption spectroscopy, nanoparticles for bioimaging applications.

List of Text Books:	
1.	Nano Electronics and Information Technology: Rainer Waser (John Wiley)
2.	Nanoelectronics Principles and Devices: M. Dragoman & D. Dragoman (Artech House Publishers)
3.	Nano-Electronic Devices Semiclassical and Quantum Transport Modeling: D. Vasileska& S.M. Goodnick (Springer)
4.	Fundamentals of Nanoelectronics: George W. Hanson (Pearson)
5.	Photonics: Nanophotonic Structures and Materials: David L Andrews (Wiley)
URLs:	
1.	https://nptel.ac.in/courses/117/108/117108047/
2.	https://nptel.ac.in/courses/118/104/118104008/
3.	https://www.youtube.com/watch?v=wdNFCWLuC10&list=PLbMVogVj5nJT8RG5Q4CpsJXi GqXE6t8N1
4.	https://www.youtube.com/watch?v=RnUGSDW-Tfk

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: I**	**Year: 2026**
Name of Course	**Carbon Nanomaterials**		
Course Code	**PY SQ 1162**		
Core / Elective / Other	**Elective - 2**	**Credit: 3**	

Course Objective: This course aims to introduce students to the fundamentals of Carbon nanomaterials and its physical properties, Special synthesis techniques and Characterizations of Carbon Nanomaterials.

Course Outcomes:

- CO1. To study the Crystal structure of selected carbon nanomaterials: CNT, Graphene, nano crystalline diamond, Electronic Band structure of CNT and Graphene.
- CO2. To study Thermal transport and electron-phonon interaction, Effect of structural disorder, Elastic Properties, Optical response.
- CO3. To understand the various techniques of CNTs and Graphene- Arc Discharge, Thermal CVD, Microwave plasma CVD, Laser Ablation, Growth mechanism.
- CO4. To understand characterization of Carbon Nanomaterials: Raman spectroscopy, SEM, HRTEM, AFM, STM.
- CO5. Study of applications of CNTs and Graphene.

Syllabus:

Introduction to Carbon nanomaterials and its physical properties: C-C bonding, Types of carbon fullerenes, Crystal structure of selected carbon nanomaterials: CNT, Graphene, nano crystalline diamond, Electronic Band structure of CNT and Graphene, Electrical transport properties of graphene & CNTs, Thermal transport and electron-phonon interaction, Effect of structural disorder, Elastic Properties, Optical response.

Synthesis and Characterizations: Brief introduction to various techniques of CNTs and Graphene- Arc Discharge, Thermal CVD, Microwave plasma CVD, Laser Ablation; Growth mechanism; Special synthesis techniques- Vertical aligned growth of CNT, Selective area growth of CNT, single walled CNT growth, large area graphene synthesis, nano-patterning on graphene, Characterization of Carbon Nanomaterials: Raman spectroscopy, SEM, HRTEM, AFM, STM.
Applications of CNTs and Graphene: Field emission, Electronic Devices, Optoelectronic devices, Chemical and Biological sensors.

List of Text Books:

1.	Handbook of Carbon, Graphite, Diamond, and Fullerenes, O. Pierson Hugh
2.	The properties of Carbon Nanotube Devices, Francois Leonard
3.	Phaedon Avouris, Carbon Nanotubes: Synthesis, Structure, Properties, and Applications, M. S. Dresselhaus, G. Dresselhaus
4.	Graphene: Carbon in Two Dimensions, Mikhail I. Katsnelson

5.	Graphene Nanoelectronics: Metrology, Synthesis, Properties and Applications, Hassan Raza
6.	Science of Fullerenes and Carbon Nanotubes: Their Properties and Applications, M. S. Dresselhaus, G. Dresselhaus, P. C. Eklund
URLs:	
1.	http://www.physics.dcu.ie/~jpm/PS407/dot.pdf
2.	https://www.nanotech-now.com/
3.	https://nptel.ac.in/courses/113/106/113106040/
4.	http://stanford.edu/~oas/SI/QM/papers/QMGreensite.pdf

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: I**	**Year: 2026**
Name of Course	**Quantum Algorithm and Complexity**		
Course Code	**CS QC 1103**		
Core / Elective / Other	**Elective - 2**	**Credit: 3**	

Course Objective:

To provide a comprehensive understanding of quantum algorithms and complexity, covering classical vs quantum complexity classes, foundational algorithms like Grover's and Shor's, quantum Fourier transform, variational methods, Hamiltonian simulation, quantum walks, and their implications for cryptography, limitations, and emerging applications in quantum machine learning.

Course Outcomes:

- 1. Understand classical vs quantum computational complexity classes.
- 2. Study important quantum algorithms and their speedups.
- 3. Analyze Grover's quadratic speedup and Shor's exponential speedup.
- 4. Evaluate algorithmic complexity and quantum lower bounds.
- 5. Explore implications of quantum algorithms on cryptography.

Syllabus:

Classical complexity classes (P, NP, NP-Complete), introduction to quantum complexity classes (BQP, QMA), quantum oracle models, Deutsch and Deutsch-Jozsa algorithms, Bernstein-Vazirani algorithm, Simon's problem and its exponential separation, Grover's search algorithm and amplitude amplification, Quantum Fourier Transform (QFT), phase estimation algorithm, Shor's factoring algorithm and discrete logarithms, hidden subgroup problems, introduction to quantum walks, Hamiltonian simulation basics, variational quantum algorithms (VQE, QAOA), quantum cryptanalysis implications on RSA and ECC, quantum lower bounds and limitations, recent algorithmic developments in quantum machine learning (overview).

List of Text Books:

1.	Quantum Algorithms via Linear Algebra by Richard J. Lipton and Kenneth W. Regan
2.	Quantum Computation and Quantum Information by Nielsen & Chuang (specific chapters)

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Thin Film & Vacuum Technology**		
Course Code	**PY SQ 1251**		
Core / Elective / Other	**Elective - 3**	**Credit: 3**	

Course Objective: To provide a comprehensive understanding of various physical and chemical deposition methods, such as thermal evaporation, sputtering, molecular beam epitaxy, and chemical vapor deposition. These objectives aim to ensure that students gain both theoretical knowledge and practical skills, preparing them for careers in industries and research fields that utilize thin film technology.

Course Outcomes:

- CO1: Explain the basics of thin film techniques.
- CO2: Explain the nucleation and growth mechanism of different thin film deposition techniques.
- CO3: Differentiate the working and principle of different thin film deposition techniques.
- CO4: Apply the knowledge of deposition techniques in the experimental lab to fabricate electronic devices.
- CO5: Apply the knowledge of deposition techniques at research as well as in industry.

Syllabus:

Vacuum components and systems: Need for vacuum, ways to achieve vacuum, determination of vacuum, dry and vapour pumps, pressure measurement gauges, conductance and other system design considerations.

Thin film deposition techniques: Physical and chemical vapour deposition techniques including molecular beam epitaxy, laser ablation and hot wire and microwave CVD techniques. Film contamination, cosine law of deposition, conformal coverage and line of sight deposition.

Growth of thin films: Thermodynamic and kinetic considerations of deposition of thin films by both CVD and PVD. In situ characterization of thin film deposition process.

Characterization of thin films: Different methods of thickness measurements, electrical, optical, chemical and structural property determination.

Some important applications of thin films: Hard and decorative coatings, semiconductor thin films, organic thin films.

List of Text Books:

1.	Handbook of Analytical Instruments: R. S. Khandpur (McGraw Hill)1. Thin Film Deposition and
2.	Patterning: R. K. Waits, American Vacuum Society, 1998.
3.	The Materials Science of Thin Films: M. Ohring, Academic Press, Boston, 1991.

4.	Physics of Thin Films: Ludmila Eckertova, 2nd Plenum Press New York, 1986.
5.	Thin Film Phenomena: K. L. Chopra, McGraw-Hill, 1969.
URLs:	
1.	https://www.youtube.com/watch?v=wFVVuHyx200
2.	https://nptel.ac.in/courses/127105531
3.	https://www.youtube.com/@DrPervaizAhmad
4.	https://www.youtube.com/@surfaceengineeringofnanoma4417
5.	https://www.youtube.com/watch?v=ev1EiLWgDIs
6.	https://www.youtube.com/watch?v=RzIa_WGcsRQ

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Solar Photovoltaic and Energy Storage**		
Course Code	**PY SQ 1252**		
Core / Elective / Other	**Elective - 3**	**Credit: 3**	

Course Objective:

The objective of the course is to provide students with a comprehensive understanding of the principles, technologies, and applications of solar photovoltaic systems.

Course Outcomes:

- CO1: To understand photovoltaic systems, applications for photovoltaic systems
- CO2: Identify practices and protective equipment used for PV systems.
- CO3: Describe Production of single crystal silicon:Czokralski (CZ) and Float Zone (FZ) method
- CO4: Understand the solar cell parameters; I-V curve & L-I-V characteristics
- CO5: Use software tools for simulating and optimizing PV system performance. Design a photovoltaic solar cell

Syllabus:

Review of Semiconductor Physics: Electrons and holes in semiconductors, doping, electrical transport, Photo carrier generation and recombination; p-n and p-i-n Junctions; metal semiconductor contacts, band bending, Ohmic and rectifying contacts, Surface and interface states, homo and hetero-junctions; Depletion region, depletion capacitance, Carrier and current densities, Current voltage characteristics in dark and light

Device Physics of Solar Cells: Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell. Semiconductor properties, energy levels, basic equations. Solar cell, p-n junction, structure. Solar radiation, conversion efficiency, p-n junction model, Effect of Parasitic resistance, irradiation and temperature on I-V characteristics. Numerical solar cell modeling

Principle of cell design: Cell type, Optical design, surface and bulk recombination losess, design and fabrication of metal contacts, Crystalline Silicon and III-V Solar cells: Single, tandem and multi-junction solar cells, Thin Film Solar cells: Amorphous silicon, cadmium telluride and copper indium gallium di-selenide based solar cells

Photovoltaic System Engineering: Thermo-photovoltaic generation of electricity, Concentration and storage of electrical energy, photovoltaic modules, system and application
Nanomaterial for photovoltaic: Photochemical solar cells, PV panels with nanostructures. Phase compositions on nanoscale microstructures – role of nanostructures and materials – nanomaterials in solar photovoltaic technology- band gap engineering and optical engineering - tandem structures - quantum well and quantum dot solar cells - photo-thermal cells – organic solar cells. Performance and reliability of nanomaterials based solar cells.

List of Text Books:

1.	Solar Photovoltaics: Fundamentals, Technologies and Applications, Chetan Singh Solanki,
2.	Solar Cells and their Applications: Larry D. Partain (ed.), (John Wiley and Sons)

3.	The Physics of Solar Cells: J. Nelson, (Imperial College Press)
4.	Photovoltaic Materials, R. H. Bube, (Imperial College Press)
List of Reference Books:	
1.	Photovoltaic Systems: Jim Dunlop (An American Technical Publishers, INC. publication)
2.	Photovoltaic Systems: National Joint Apprenticeship and Training (Amer Technical Pub;)
3.	Physics of Solar Cells: Peter Würfel, UliWürfel (Wiley-VCH)
URLs:	
1.	https://archive.nptel.ac.in/courses/115/107/115107116/
2.	https://onlinecourses.nptel.ac.in/noc20_mm05/preview

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Instrumentation**		
Course Code	**PY SQ 1253**		
Core / Elective / Other	**Elective-3**	**Credit: 3**	

Prerequisite:	
1.	Basic knowledge of Materials Science & Engineering
Course Outcomes:	
CO1	In-depth knowledge about instruments used for different characterization techniques
CO2	Study of theory, construction and working mechanism of instruments used for understanding electrical, ferroelectric and dielectric properties of materials, electrochemical properties of materials
CO3	Detailed study of instruments used for Electron micrography, phase identification, Spectrophotometry
CO4	Understanding the techniques like NMR, ESR, FTIR, Raman for nanostructure characterization
CO5	Uses and applications of different types of Vacuum gauges and thin film thickness monitor

Syllabus:

Electrical & thermal properties measurements: Resistivity, dielectric, thermoelectric, specific heat, Hall effect, Ferroelectric, Piezoelectric, Pyroelectric properties. Magnetic properties: VSM, SQUIDS, MFM, Susceptibility, Magneto-optical Kerr effect. Thermal analysis: TGA-DTA, DSC. Vacuum pumps (Turbo and ultra-high vacuum), Measurement of Low pressure - penning and pirani gauge. Film thickness measurement. Compositional analysis: Electron probe micro analysis (EPMA), Auger electron spectroscopy (AES), Inductive coupled plasma-mass spectroscopy (ICP-MS). Spectroscopic techniques: UV-VIS, NMR, ESR, Ferromagnetic resonance (FMR), Raman Spectroscopy, FTIR. Particle analysis: Dynamic light scattering (DLS), BET surface area analyzer. Small Angle X-ray Scattering, X-ray absorption spectroscopy (XAFS, XANES), Electrochemical impedance spectroscopy.

List of Text Books:

1.	Handbook of Analytical Instruments: R. S. Khandpur (McGraw Hill)
2.	A Textbook of Nanoscience and Nanotechnology:P. I. Varghese, T. Pradeep (McGraw Hill)
3.	Spectroscopic Methods for Nanomaterials Characterization: Sabu Thomas, Raju Thomas, Ajesh K. Zachariah, Raghavendra Kumar Mishra (Elsevier)
4.	Microscopy Methods in Nanomaterials Characterization:Sabu Thomas, Raju Thomas, Ajesh K. Zachariah, Raghavendra Kumar Mishra (Elsevier)
5.	Principles of Nanomagnetism,Alberto P. Guimarães (Springer)

6.	Differential Scanning Calorimetry: An Introduction for Practitioners:G.W.H. Höhne, W. Hemminger (Springer)
7.	Characterization of Porous Solids and Powders: Surface Area, Pore Size and Density: S. Lowell, Joan E. Shields, Martin A. Thomas, Matthias Thommes (Springer)
List of Reference Books:	
1.	Analytical Instrumentation Handbook: Jack Cazes and Jack Cazes (CRC Press)
2.	Elements of X-ray Diffraction, B. D. Culity (Pearson, UK)
3.	Introduction to magnetic materials, B. D. Culity (Wiley)
4.	Handbook of Thin Film Technology: Leon I. Maissel, R. Glang (McGraw Hill)
5.	Thermal Methods of Analysis: W. W. Wendland (Wiley-Blackwell)
6.	X-Ray Absorption and X-Ray Emission Spectroscopy: Theory and Applications: Jeroen A. Van Bokhoven, Carlo Lamberti (Wiley)
7.	Ferroelectrics: Principles and Applications, Ashim Kumar Bain, Prem Chand (Wiley)
8.	Handbook of Vacuum Technology,Karl Jousten (Wiley)
9.	Miniaturization and Mass Spectrometry: Severine le Gac, Albert van den Berg (Royal Society of Chemistry)
10.	Thermal Analysis Techniques and Application: E. L. Charsley, & S. B. Warrington (Royal Society of Chemistry)
11.	Thermal Analysis: Fundamentals and Applications to Polymer Science, T. Hatakeyama. & F. X. Quinn (John Wiley & Sons)
URLs:	
1.	https://web.njit.edu/~tyson/PPMS_Documents/PPMS_Manual/1070150%20Rev.%20B5%20PQ%20%20PPMS%20Hardware.pdf
2.	http://four-point-probes.com/four-point-probe-manual/
3.	https://nptel.ac.in/courses/118/104/118104008/
4.	https://nptel.ac.in/courses/113/107/113107081/
5.	https://physlab.lums.edu.pk/images/e/eb/Reframay4.pdf
6.	http://academy.cba.mit.edu/classes/input_devices/meas.pdf
7.	https://www.iucr.org/education
8.	https://www.rrcat.gov.in/technology/accel/srul/beamlines/exafs.html#intr
9.	http://csr.res.in/indore_centre_facilities_link_page1.html

10.	https://crimsonpublishers.com/mapp/pdf/MAPP.000509.pdf
11.	https://nptel.ac.in/courses/113106064/
12.	https://nptel.ac.in/content/storage2/courses/112108150/pdf/PPTs/MTS_16_m.pdf
13.	https://nptel.ac.in/courses/115103030/
14.	https://www.elsevier.com/data/promis_misc/622954sc1.pdf
15.	https://www.iitk.ac.in/ibc/Vacuum_Gauges.pdf
16.	https://www.ferrodevices.com/1/297/files/Ferroelectric_Properties_and_Instrumentation(1).pdf
17.	https://www.horiba.com/en_en/raman-imaging-and-spectroscopy/
18.	https://www.lehigh.edu/imi/teched/GlassCSC/SuppReading/Tutorials.pdf
19.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2777224/
20.	https://www.gamry.com/application-notes/battery-research/testing-electrochemical-capacitors-cyclic-voltammetry-leakage-current/
21.	https://www.shimadzu.com/an/uv/support/uv/ap/film.html
22.	https://www.jawoollam.com/resources/ellipsometry-tutorial

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Quantum Machine Learning and Deep Learning**		
Course Code	**CS QC 1201**		
Core / Elective / Other	**Elective -3**	**Credit: 3**	

Course Objective:

To introduce the principles and techniques of quantum machine learning by integrating classical ML concepts with quantum approaches such as quantum data encoding, variational classifiers, hybrid quantum-classical models, quantum neural networks, and optimization algorithms, while exploring their potential advantages, practical challenges, and applications across domains like chemistry, finance, and combinatorial optimization.

Course Outcomes:

- Understand the principles and motivation behind merging quantum computing with
- machine learning.
- Learn foundational quantum machine learning algorithms and their classical
- counterparts.
- Explore quantum-enhanced feature spaces and kernel methods.
- Study deep learning architectures and potential quantum speedups.
- Analyze applications of quantum ML in optimization and generative models.

Syllabus:

Overview of classical machine learning and deep learning, quantum feature spaces and quantum data encoding, quantum support vector machines, variational quantum classifiers, quantum kernel estimation, hybrid quantum-classical neural networks, quantum circuit learning, quantum Boltzmann machines, parameterized quantum circuits (ansätze) for supervised tasks, quantum generative adversarial networks (QGANs), quantum reinforcement learning basics, quantum optimization via QAOA, potential quantum speedups in deep learning training, challenges of noise and barren plateaus in quantum ML, recent advances in quantum natural gradient and quantum autoencoders, applications in chemistry, finance, and combinatorial problems.

List of Text Books:

1.	Quantum Machine Learning: What Quantum Computing Means to Data Mining by Peter Wittek
2.	Machine Learning with Quantum Computers by Maria Schuld & Francesco Petruccione

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Materials Science and Engineering**		
Course Code	**PY SQ 1261**		
Core / Elective / Other	**Elective - 4**	**Credit: 3**	

Course Objective:

To provide students with a foundational understanding of material structures, phase transformations, mechanical behavior, and functional properties, enabling them to analyze and apply material science principles in engineering applications.

Course Outcomes:

By the end of the course, students will be able to:

- Interpret phase diagrams and understand phase transformations in materials.
- Analyze microstructural evolution and its effect on material properties.
- Evaluate mechanical and thermal behavior through stress-strain analysis and crystallization processes.
- Understand electrical and dielectric properties of materials, including polarization and ferroelectric effects.
- Classify magnetic materials and explain their properties and applications, including multiferroics and electroceramics.

Syllabus:

Introduction to materials, phase rule, single component system, Binary Phase diagrams Microstructural changes during cooling, Lever Rule, Some typical phase diagrams, Time scale for phase changes, nucleation and growth, nucleation kinetics, growth kinetics and overall kinetics, Stress-strain curve, thermal properties, microstructure, strength of materials, Solidification and crystallization, the glass transition.Types of polarization, complex dielectric constant, polar and non-polar materials, Dielectric breakdown, piezoelectricity, ferroelectricity, electroceramics, multilayer capacitors. Magnetic parameters, classification of magnetic materials, Ferromagnetic materials, ferrites, Applications of magnetic materials, Multiferroics.

List of Textbooks:

1.	Materials Science and Engineering: AFirst Course by V. Raghavan
2.	Materials Science and Engineering – An Introduction by W.D. Callister Jr.
3.	Materials Science by J. C. Anderson, K. D. Leaver, R.D. Rawlings and J.M. Alexander

List of Reference Books:

1.	Materials Science and Engineering: AFirst Course by V. Raghavan
2.	Electrical Properties of Materials, seventh Edition by L.Solymar and D. Walsh

3.	Principles of Materials Science and Engineering by William Smith
URLs:	
1.	https://archive.nptel.ac.in/courses/113/102/113102080/
2.	https://archive.nptel.ac.in/courses/113/107/113107078/

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Materials Properties at Low Temperatures**		
Course Code	**PY SQ 1262**		
Core / Elective / Other	**Elective - 4**	**Credit: 3**	

Course Objective:

This paper is useful to learn essential theoretical elements and the principal measurement methods to understand the magnetic and thermal properties of the materials which will be useful in research and development of cryogenic technology.

Course Outcomes:

Upon completion of the course, students will be able to:

- CO1. To understand the concept of thermodynamics & liquefaction of gases, Cryostat design, Transport Phenomenon Fermi surface, Magnetism. Conductivity of solids, Technique of measurement.
- CO2. Study of Paramagnetic & Nuclear adiabatic demagnetization.
- CO3. Detailed knowledge about Fundamental phenomena of superconductivity, Meissner effect, London equation, Type I and Type II superconductors, qualitative idea of Cooper pairing and BCS theory.
- CO4. Study of Ginsburg-Landau theory, coherence length, Green's functions of electrons and phonons.
- CO5. Understanding of Superconductor in a field, flux quantization effect, SQUIDS, High-T_c materials.

Syllabus:

Thermodynamics & liquefaction of gases, Cryostat design, Transport Phenomenon, Fermi surface, Magnetism. Conductivity of solids, Technique of measurement, Paramagnetic & Nuclear adiabatic demagnetization. Superconductivity. Fundamental phenomena of superconductivity, Meissner effect, London equation, Type I and Type II superconductors, qualitative idea of Cooper pairing and BCS theory.

Ginsburg-Landau theory, coherence length, Green's functions of electrons and phonons, isotope effect, The BCS Hamiltonian, the gap parameter, Superconductor in a field, flux quantization effect, SQUIDS, High-T_c materials

List of Text Books:

1.	Superconductivity: Werner Buckel& Reinhold (Wiley-VCH)
2.	Thermodynamics: M.S. Yadav (ANMOL PUBLICATIONS)
3.	Thermodynamics: Enrico Fermi (Dover Publications, INC. Mineola New York)
4.	Handbook of Superconducting Materials: David A. Cardwell, David S. Ginley (Institute of Physics Publishing Limited)
5.	Introduction to Superconductivity: Michael Tinkham (Dover Publications, INC. Mineola New York)

6.	Superconductivity, superfluids, and condensates, James F. Annett Publisher, Oxford University Press
URLs:	
1.	https://nptel.ac.in/courses/115101012/
2.	https://nptel.ac.in/courses/112/101/112101004/
3.	https://nptel.ac.in/content/storage2/courses/113106062/Lec7.pdf
4.	https://nptel.ac.in/courses/112108148/
5.	https://nptel.ac.in/courses/112105266/

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Defects in Materials**		
Course Code	**PY SQ 1263**		
Core / Elective / Other	**Elective - 4**	**Credit: 3**	

Syllabus:

Review of defect classification and concept of defect equilibrium. Review of point defects in metallic, ionic and covalent crystals. Dislocation theory - continuum and atomistic. Dislocations in different lattices. Role of anisotropy. Dislocation kinetics. Interface thermodynamics and structure.

Overview of grain boundaries, interphase boundaries, stacking faults and special boundaries. Interface kinetics: migration and sliding. Defect interactions: point defect-dislocation interaction, dislocation interface interactions, segregation, etc. Overview of methods for studying defects including computational techniques

List of Text Books:

1.	Introduction to Dislocations D. Hull (Author), D. J. Bacon (Author), Butterworth-Heinemann
2.	Elementary Dislocation Theory, Johannes Weertman, Julia R. Weertman, Oxford Univ. Press
3.	A. Kelly, G. W. Groves, and P. Kidd, Crystallography and Crystal defects, John Wiley and Sons, 2000
4.	P. G. Shewmon, Diffusion in solids, McGraw Hill
5.	R. E. Reed-Hill, Principle of physics metallurgy, Cengage Learning
6.	D. E. Dieter, Mechanical metallurgy, Metric editions

Name of Program	**M. Tech. (Semiconductor and Quantum Technology)**	**Semester: II**	**Year: 2026**
Name of Course	**Optoelectronics**		
Course Code	**PY SQ 1264**		
Core / Elective / Other	**Elective - 4**	**Credit: 3**	

Course Objective: This course aims to introduce students to the fundamentals and applications of spintronics, nanoscale solid-state devices, nanophotonics, and liquid crystals.

Course Outcomes:

- CO1. Study the application of electronic devices and systems that produce, detect and control light.
- CO2. Establish the concept of light guidance in optical fibers and discuss types, rays, modes and losses in optical fibers
- CO3. Study the various fabrication techniques and applications of fiber optical cables.
- CO4. Demonstrate the use of optical fiber interconnectors and optical waveguides.
- CO5. Introducing the concept of Nonlinear optics-generation of harmonics-its applications like Kerr effect, Pockel's effect, Faraday effect.
- CO6. Study the concepts, principles and applications of magneto optics.

Syllabus:

Interaction of photons with atoms, spontaneous emission, stimulated emission and absorption, line broadening, the laser amplifier, theory of laser oscillation, characteristics of laser output, characteristics of common lasers.

Semiconductors- energy bands and charge carriers, binary, ternary and quaternary semiconductors,
generation, recombination and injection processes, junctions, heterojunctions, quantum wells, superlattices, interaction of photons with electrons and holes, band-to-band absorption and emission, rates of absorption and emission, refractive index. Light emitting diodes, injection electroluminescence, LED characteristics, semiconductor laser amplifier, gain, pumping, heterostructures, semiconductor injection lasers, amplification, feedback and oscillation, power, spectral distribution, mode selection, characteristics of typical semiconductor lasers, quantum well lasers.

Properties of semiconductor photodetectors, quantum efficiency, responsivity, response time, Photoconductors- photodiodes, p-n and p-i-n photodiode, heterostructure photodiodes, array detectors, avalanche photodiodes, noise in photodetectors Principles of electron optics, Pockels and Kerr effects, electro-optic modulators and switches, scanners, directional couplers, spatial light modulators, electro-optics of anisotropic media and liquid crystals,

photorefractive materials Integrated optic planar waveguides, mechanism of light guidance, integrated optic components, directional coupler, optical fiber, step-index, graded-index, single-mode fibers, optical fiber components, fused fiber coupler, fiber Bragg gratings, long-period fiber gratings, sources for optical transmitters, detectors for optical receivers, fiber-optic systems.	
List of Text Books:	
1.	Fundamentals of Photonics, B. E. A. Saleh and M. C. Teich, John Wiley and Sons, Inc
2.	Optical Electronics, A. Ghatak and K. Thyagarajan, Cambridge University Press
3.	Quantum Electronics, A Yariv, 3 Ed., John Wiley and Sons
4.	Solid State Electronic Devices, B. G. Streetman and S. Banerjee, 6 Ed. Prentice Hall
URLs:	
1.	https://nptel.ac.in/courses/117/108/117108047/
2.	https://nptel.ac.in/courses/118/104/118104008/
3.	https://www.youtube.com/watch?v=wdNFCWLuC10&list=PLbMVogVj5nJT8RG5Q4CpsJXi GqXE6t8N1
4.	https://www.youtube.com/watch?v=RnUGSDW-Tfk